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Measuring the Farm Level Impact of Agricultural Loans in Low Income Countries: A Review Article*

by

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ABSTRACT

Billions of dollars are spent worldwide on agricultural credit programs, yet few comprehensive evaluations exist. This paper reviews several methodological issues involved in measuring the farm level impact of agricultural loans. Fungibility of loan funds, farm-household interdependence, and the attribution problem are three issues which are reviewed in detail. A farm resource allocation model is used to analyze expected impact of loans on the farm. Recent descriptive, econometric and mathematical programming studies of loan impact in low income countries are reviewed relative to these issues and the resource allocation model. Suggestions are given for improved research and data collection.

INTRODUCTION

Expansion of formal agricultural credit has been a major policy in many low income countries in recent years. In Latin America alone, formal agricultural credit was almost $8 billion in 1973 and the current amount in all low income countries could range from $30 to $40 billion [25]. Given concessionary interest rates, high administrative costs, and low repayment rates, substantial subsidies are required to continue this policy in many countries. There is growing concern, however, that this credit has not led to desired improvements in farm income, production and income distribution.

This paper reviews selected studies of the impact of agricultural credit programs. The objective is to summarize key conceptual problems and analyze important methodological alternatives.1/ We first briefly present a conceptual framework of the potential impact of credit on farm resource allocation. This framework is used to identify general methodological problems encountered in empirical research. The second section reviews the empirical literature including descriptive, econometric, and mathematical programming studies. Finally, research suggestions are given to improve estimates of benefits obtained from agricultural credit programs.

1/ An annotated bibliography of publications reviewed for this paper is available [16].

ROLE OF CREDIT IN RESOURCE ALLOCATION

An important problem in analysis of the impact of borrowing on a farm-household is the lack of a sound theoretical framework to guide empirical research.[2] Errors in specification of empirical models and misinterpretation of results are logical outcomes. Two issues are particularly troublesome. First, farm households are complex units simultaneously making production and consumption decisions. Secondly, given fungibility in farm-household cash flow management, it is difficult to identify the effects of loans on the farm versus the household. But, since formal credit is usually intended to increase production, not consumption, many researchers assume that production loans are actually used for production. It is necessary, as a result, to present a conceptual role of credit in farm production as background for the research review.

Consider the typical neo-classical farm production model with a savings constraint represented by S. Given product price P, input prices P_i's, and continuous, twice differentiable production function $f(X_1, X_2. . . X_n)$, the farm is assumed to maximize profits subject to the condition that production costs not exceed savings. The profit equation is:

$$\Pi = [P^*f(X_1,X_2,. . . X_n) - \Sigma P_i X_i] + \lambda\ (S - \Sigma P_i X_i)$$

2/ This issue is discussed in greater detail in another paper [17].

where λ is the Lagrange multiplier. The equilibrium conditions are:

$Pf_i = P_i(1+\lambda)$, where f_i is the marginal product for each input i from 1 to n, and

$S = \Sigma P_i X_i$

Normally, λ is assumed zero and the farm equates marginal value product to input price. When savings are limited, λ denotes the farmer's marginal time preference for present over future consumption or, if a financial market exists, the effective cost of borrowing. Optimal input use, output, and net farm income are expected to be lower when λ is not zero.[3/]

The implications of these equilibrium conditions on farm resource allocation are shown in Figures 1a and 1b relating output to input X_i and marginal value product of X_i, respectively, assuming the usual ceteris paribus conditions. With no financial constraint, optimal levels of output and input use are Q^* and X_1^*, respectively. Financial constraints, imperfect knowledge and risk factors may cause departure from these optimal levels. Assuming perfect knowledge and certainty, input usage of X_i^o and production of Q^o implies an effective cost of credit or marginal time preference between present and future consumption of λ. A credit program which lowers the

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3/ Baker hypothesized that financial constraints may have an effect on relative input costs and, therefore, relative factor use, e.g., capital becomes relatively more expensive than labor [7]. However, fungibility of money or credit reduces this effect.

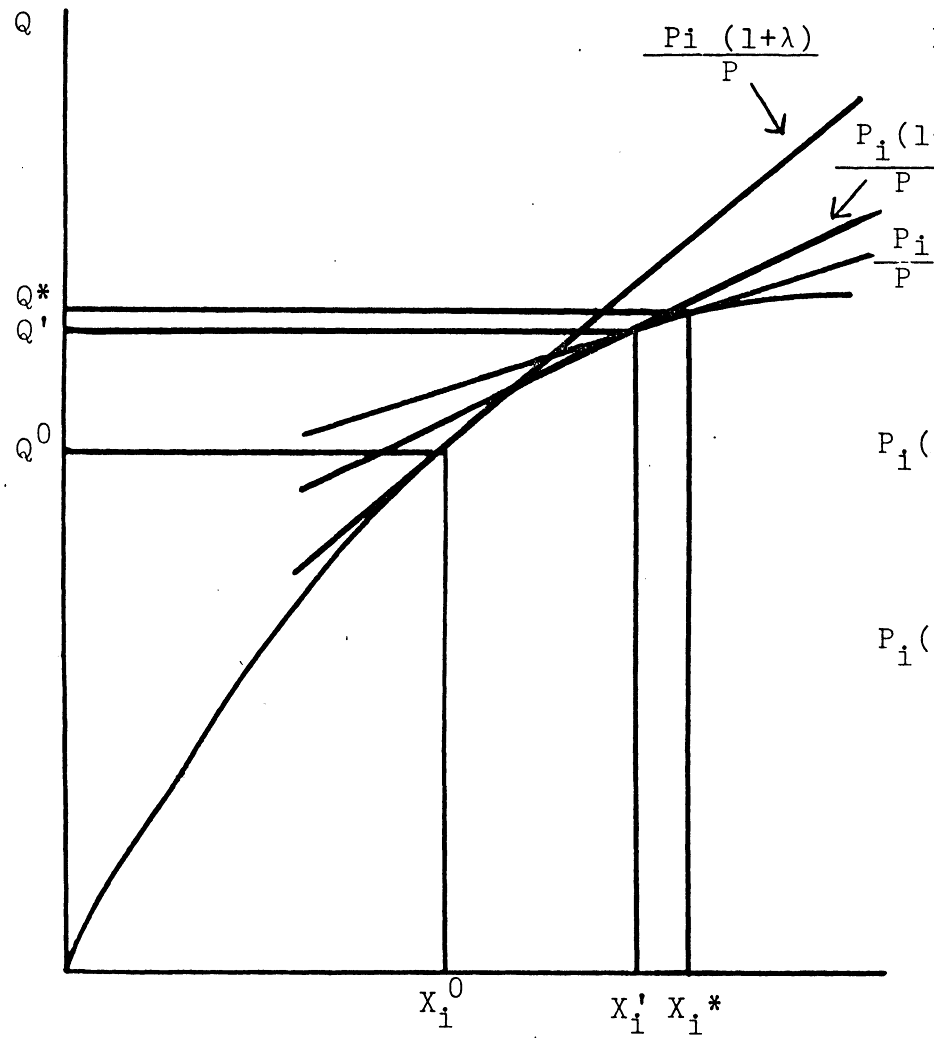

FIGURE 1a: Effect of Credit on Input Use and Production

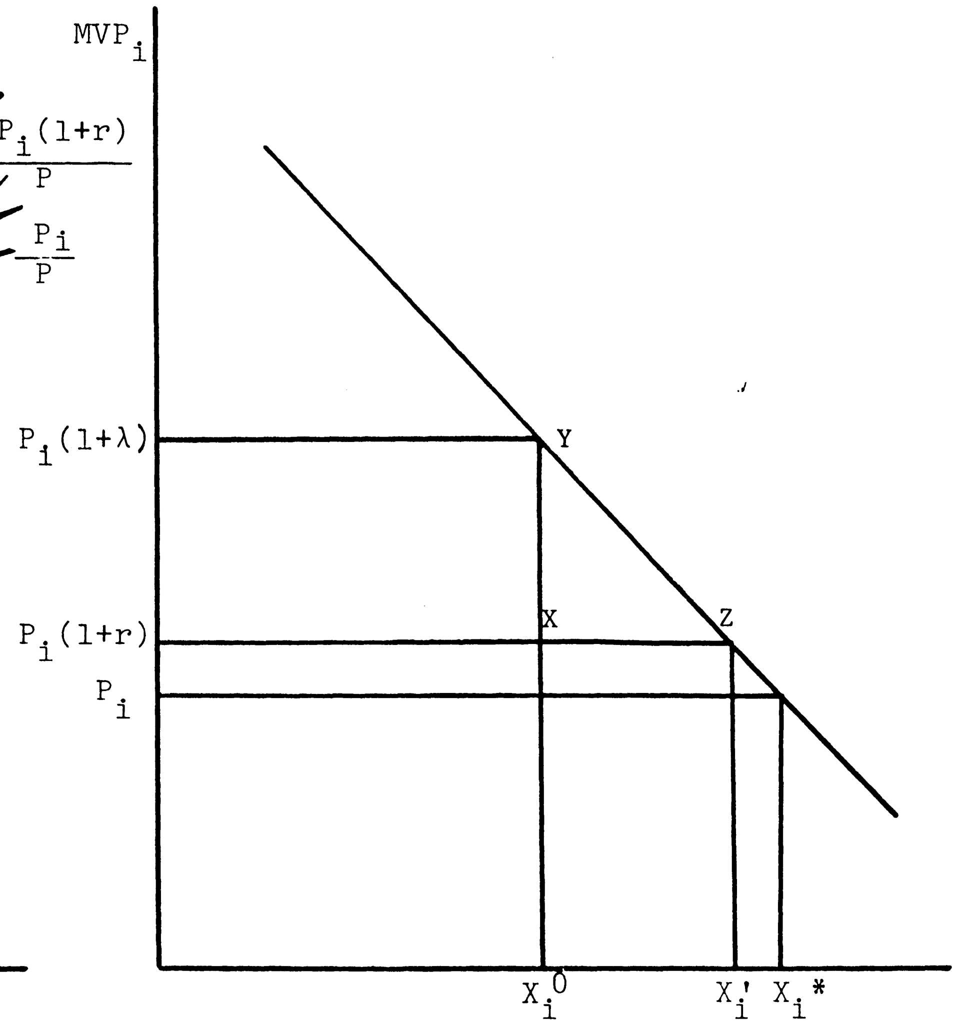

FIGURE 1b: Effect of Credit on Input Use and Marginal Value Product (MVP)

effective cost of borrowing to r increases optimum input use to X_i', production to Q', and net farm income by YXZ. The increase in net farm income represents the benefit of borrowing to the individual farm. Private benefits equal social benefits if r is the equilibrium interest rate determined by market forces.

The empirical measurement of the total benefits of borrowing is much more complex than implied by this simplified model. Focusing on the farm rather than the farm-household ignores possible welfare effects of borrowing through increases in consumption and non-farm activities. The true effect of borrowing is the additionality which occurs in farm input use and output but, due to fungibility, loans from a formal program may simply substitute for own savings or other sources of loans [34, 45]. Accounting for substitution, however, may improve measurement of the impact of loans on the farm, but may understate the overall impact on the farm-household. If no impact can be detected on the farm, the additional liquidity due to credit may have substituted for savings or other loan sources or diverted to other non-farm or household uses. A more complete evaluation requires information about the household's marginal use of additional liquidity obtained from borrowing, not just the impact of the direct expenditure of loans. Such information is extremely difficult to collect through the typical cross-sectional farm surveys usually conducted for this evaluation.

Even with more comprehensive data, the problem remains of isolating the effect of loans on observed differences between borrowers and non-borrowers or before and after borrowing. This has been referred to recently as the attribution problem [34]. At least four factors other than credit can explain differences between borrowing and nonborrowing households:

1. differences in shifters of the production functions, such as technology, technical information, irrigation, weather, and other variables not easily quantified in production models;
2. differences in factors explaining nonoptimal input use, such as yield and price uncertainty, and management ability;
3. differences in product and input prices; and
4. differences in own financial constraints or savings.

Multipurpose agricultural credit programs contribute to the attribution problem. Although credit is the central part of these programs, intensive extension services and input subsidies are frequently involved. Many studies assume that extension explains little of the differences found between borrowers and nonborrowers.[4/] However, the effect of input subsidies on input use and production may be significant and needs to be separated from the impact of credit.

Concessionary interest rates, characteristic of most credit programs, further complicate research. The resulting excess demand for loans implies non-price rationing which typically favors

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4/ The study by Scobie and Franklin represents one of the few systematic attempts to evaluate extension in supervised credit programs.

large loans to farmers with greater factor endowments, access to better technical information and better management. Therefore, borrowers may be systematically different from nonborrowers with borrowing the result rather than the cause.

REVIEW OF EMPIRICAL LITERATURE

Surprisingly little research has evaluated the impact of the vast sums spent on agricultural credit programs. For example, the comprehensive 1973 AID Spring Review contained about 60 papers describing various credit programs but no papers systematically assessed the farm level impact of loans [3]. Some studies reported trends in aggregate output, use of inputs, and adoption of new varieties, while lamenting the scarcity of data to conduct more detailed analysis. This section analyzes selected studies concerning the farm level impact of borrowing.

Descriptive Studies

The most common analysis of credit programs is the comparison of farm input, production, and productivity before and after borrowing by borrowers or between borrowers and non-borrowers. Few descriptive studies are widely available, but many undoubtedly exist as unpublished reports or graduate student theses. Table 1 summarizes the results of selected descriptive studies to illustrate the variables examined and the impact usually attributed to borrowing. Additional analysis was performed using econometric techniques (Colombia) or by

TABLE 1: Percent Differences in Selected Measures Between Borrowers and Nonborrowers, Selected Countries

Countries/Years	No. of Obser-vations	Farm Size	Percent Differences in: Operating Expenses per Hectare	Invest-ment per Hectare	Produc-tion per Hectare	Net Farm Income per Hectare
Brazil (1965)	132	78	112	n.a.	30[a]	2
Southern Brazil (1965)	954	94	127	80	62[a]	n.a.
(1969)	732	68	281	338	133[a]	n.a.
Colombia (1968)	52	74	104	n.a.	6	n.a.
(1968/1965)[b]	25	30	56	n.a.	35	n.a.
Guatemala (1975)	1600	5	39	n.a.	-3	0[c]
Philippines (1975-1977)[d]	577	16	15	n.a.	n.a.	4
[e]	497	2	-15	n.a.	n.a.	0
Korea (1970)	438	3	5	5	n.a.	-1
Taiwan (1965, 1970, 1975)	1373	16	21	n.a.	8	-2

[a] Gross farm income per hectare.

[b] Comparison of borrowers before (1965) and after (1968) the credit program.

[c] Based on lower 75 percent of farms in size.

[d] Nonborrowers include those who borrowed from non-formal institutions.

[e] Comparison of borrowers fron non-formal sources and nonborrowers.

Sources: Brazil [6], Southern Brazil [38], Colombia [13], Guatemala [15], Philippines [14], and Korea [30]. The Taiwan figures were computed from time series, cross section farm household record-keeping data available at the Department of Agricultural Economics and Rural Sociology, Ohio State University.

investigating factors affecting demand for credit (Korea, Brazil).

Except for Colombia, these studies were cross-sectional analyses of borrowers and non-borrowers.[5/] Longitudinal data from panel farms would minimize some attribution problems, but would magnify the influence of weather, insects and diseases which often dominate year to year yield variations. "Before and after" comparisons are fewer because evaluation is generally initiated after the program begins so quantification of the "before" situation is based on questionable farmer recall.

These studies represent widely different types of agriculture and credit programs. The Latin American studies cover relatively large farms producing multiple crops and programs including both short and medium term loans. Asian studies refer to small monoculture rice farms receiving only short-term credit. Despite these differences, several common patterns emerge. Borrowers had larger farms than non-borrowers: 68 to 94 percent larger in Brazil and Colombia, respectively. Farm size differences in Asian countries varied only from 2 to 16 percent. The Guatemalan farms were of similar size due to the sampling procedure. Operating expenses and investment per hectare were higher for borrowers, but production differences were less marked. Moreover, net farm income per hectare, when

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5/ In the Philippines and Taiwan, the data included several years, but the sample changed from one year to another.

reported, was roughly the same.6/

Inferences about impact of loans must be treated with caution due to the attribution problem. Small differences in production and net farm income do not necessarily imply that borrowing leads to misallocation or that loans have been diverted. The impact of loans is ordinarily expected to be overstated in simple comparisons of selected variables.7/ However, uncontrolled production problems (bad weather, insects, etc.) may cause underestimation as ex post yields are lower than ex ante yields for borrowers using high levels of inputs. Thus, net profits per hectare may be similar for both groups or higher for nonborrowers.

Daines used sampling and a decomposition technique to reduce attribution errors. The sampling procedure was designed to control for potential effects of farm size and region-related factors. Differences in value of production between borrowers and nonborrowers were decomposed into price, yield, crop mix, and crop area effects. The contribution of each factor was estimated by calculating the effect if only one factor varied,

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6/ Analyzing these variables on a total farm basis is more relevant when farm size can be influenced by credit. Analysis per hectare implicitly assumes a fixed land input which is most appropriate for Asian countries where land is more constrained [23].

7/ It is interesting to note, for example, the significantly different results obtained in the Colombian study between the borrower-nonborrower and before-after credit comparisons. Borrowers' input use and yield per hectare is 104 percent and 6 percent higher, respectively, than nonborrowers. But for borrowers, input use per hectare increased only by 56 percent and yield per hectare rose 35 percent after borrowing.

implicitly assuming independence among factors and constant returns to scale. Daines concluded that the substantial expansion in crop area, which explains most production differences, was largely due to credit.

A decomposition technique was also used in a World Bank evaluation of projects providing medium and long term credit to crop farms in the Philippines, Pakistan, and Morocco and to livestock farms in Uruguay and Mexico [45]. Crop production changes were accounted for by changes in cultivated area, cropping intensity and yields, and changes in livestock production by changes in breeding cattle, feeders, reproduction rates and beef yields. Judgements were made about the probable effects of the project on each source of growth. For example, on crop farms loans were assumed to explain 20, 75, and 100 percent of the increases in yields, cropping intensity, and cultivated area, respectively. Adjustments were also made for the possible effect of other loan sources. The study concluded that the projects raised crop production by 67 percent instead of the observed unadjusted 82 percent.

The World Bank study also dealt with substitution by speculating on the farm investment that would have occurred without the project or, conversely, the additional farm investment due to the project. Three sources of information were used to derive an adjustment factor. First, borrowers were asked to estimate the investments they would have made without the program and the probable source of finance. Second, investments between borrowers and nonborrowers were compared. Third, assets financed by the project were related to the borrowers' total assets. Based on these data, a crude substitution factor of 40 percent was assumed. Thus, the credit projects explained approximately 28 percent of the net production increase rather than 67 percent.

Econometric Studies

Recent studies have used econometric techniques to analyze the impact of borrowing. Three different models have been used: a production function, an input demand function, and an efficiency gap function.

Production Function

Colombian, Brazilian and Ghanian studies hypothesized that loans influence the farm production relationship [9, 13, 37, 21]. The credit variable was specified in several ways (Table 2). The Colombian studies treated credit as a separate unit. The later Colombian study further hypothesized that borrowers have a completely different production technology so separate production functions were estimated for borrowers, nonborrowers and borrowers prior to the supervised credit program. A modified Cobb-Douglas production model was used in the Brazilian model where credit was assumed to shift production coefficients for operating expenses, modern inputs, and machinery, but not for land, labor or animal power. Similarly, the Ghanian study assumed all production parameters, except the intercept, were affected by credit. The Ghanian study used time series aggregate data, while the others used cross section farm level data.

TABLE 2: **Estimates of the Effect of Borrowing on the Cobb-Douglas Production Function, Selected Countries**

Item	Colombia 1960	Colombia: Borrower a/ 1965	Colombia: Borrower a/ 1968	Colombia: Non-Borrower 1968	Brazil 1971/72	Ghana 1962-74
Log a		1.174	2.899	0.740	1.514	0.006
Land	0.303* (1.620) b/	0.379* (1.560)	0.777* (3.964)	0.418* (1.742)	0.293* (4.42)	-2.127 (1.217)
Labor	--	0.396* (1.472)	0.049 (0.383)	0.456* (2.505)	0.009 (0.88)	4.248* (1.977)
Farm Equipment	-0.103* (-1.873)	0.144 (1.043)	0.048 (0.533)	0.034 (0.354)	0.045* (1.34)	--
Livestock	--	--	--	--	0.009* (1.83)	--
Operating Expense	0.115 c/* (1.885)	0.314* (1.377)	0.279* (1.898)	0.405* (3.092)	0.246* (4.30)	0.336 (0.269)
Modern Varieties	--	--	--	--	0.356* (5.02)	--
Credit	0.641* (3.705)	0.064 (0.877)	-0.084 (-1.000)	0.104* (1.825)	--	--
Credit x Land	--	--	--	--	--	1.559 (1.505)
Credit x Labor	--	--	--	--	--	-1.941 (-1.691)
Credit x Operating Expense	--	--	--	--	0.0001* (1.97)	-0.395 (-0.297)
Credit x Modern Inputs	--	--	--	--	-0.00003 (-0.37)	--
R^2	0.89	0.57	0.90	0.80	0.96	0.85
Number of Observations	17	27	27	25	129	13

a/ Borrowers are participants in supervised credit programs. Nonborrowers are non-participants including farmers borrowing from non-formal sources.

b/ Figures in parenthesis are t-values. Asterisk indicates statistical significance at 10 percent or better confidence interval.

c/ Includes fertilizer only.

Sources: Colombia [9, 13], Brazil [33], and Ghana [21].

These production function studies assume a somewhat different role for borrowing than presented in the first section of this paper. First, specifying credit as a separate production input presents a conceptual problem because loans may permit purchasing optimal input levels, but do not directly generate output. Double counting of inputs may also occur with credit as a separate variable. An example exists with the Colombian results where a higher production coefficient for credit was found in the earlier study. In this study the credit variable in effect captures the contribution of labor and other variables explicitly specified in the later model.

Second, attributing differences in production functions between borrowers and nonborrowers to borrowing implicitly assumes a relationship between source of liquidity and production function. A slight difference exists between borrowers and nonborrowers in the operating expense coefficient in the Colombian and Brazilian studies, but not in coefficients for other inputs, such as mechanization and modern inputs, also expected to be influenced by loans. The direction of the differences, however, is inconsistent. Insignificant coefficients in the Ghanian study, except for the very high labor coefficient, probably reflects aggregation and specification problems.

The somewhat unclear picture of loan impact is not surprising. Short-term credit programs attempt to encourage adoption of new seed-fertilizer technology, but there is little reason to expect adoption and, therefore, a shift in production function to be conditional upon borrowing. Modern varieties frequently imply greater operating expenses for optimal fertilizer and chemical use. However, seed costs are similar, fertilizer response of modern varieties is usually higher at all levels of fertilization, and fertilizer is highly divisible. Therefore, farmers with varying financial constraints should simply be located at different points on the modern technology function. Medium and long-term credit may be more closely associated with changes in the production relationship because these loans frequently finance lumpy inputs more difficult to fund internally. For example, increasing farm size introduces scale economies; expanding irrigated area raises the productivity of fertilizer, land and modern varieties; and mechanization changes land-labor relations.

The apparent difference in production coefficients between borrowers and nonborrowers, such as in land and labor in Colombia, may be due to omission of other inputs associated with loans like technical information or irrigation. Short-term loans would not be expected to have a major impact on these variables. A more plausible explanation is that progressive farmers with irrigation and better technical information borrow more. Thus, causality is as likely from higher inputs, output, income, etc. to loans as it is from loans to these changes.

Input Demand Function

Input demand studies directly test the resource allocation model presented in the first section. Schluter's comprehensive analysis of the impact of credit and uncertainty on resource allocation is an example. Input demand functions for labor, modern varieties, fertilizer, crop area, and animal and machine power were estimated. The explanatory variables included financial constraints represented by credit availability and income; ability to bear risk, measured as nonfarm assets and farm size; technology and knowledge. No significant input and output price variations were assumed to exist across the farm sample.

Table 3 presents Schluter's results only for modern varieties and fertilizer, the main targets of supervised credit programs. Access to loans, dairying income, acreage cropped, and assets were significant explanatory variables for adoption of rice varieties and fertilizer use. Schluter regards assets and farm size as indices of farmers' ability to bear risk. Farmers more able to cope with uncertainty and with more access to institutional loans were more likely to adopt modern rice varieties. Interestingly, these variables did not explain adoption of wheat varieties. Access to loans and technology (acreage in modern varieties) were the most significant factors explaining fertilizer use. Access to loans appeared to be less important, however, in explaining demand for other inputs not reported in Table 3.

Although the input demand approach does not directly test loan impact on farm production or income, it does avoid the conceptual problem of relating loans to the production function. The importance of borrowing in achieving optimal input use, however, can be better analyzed by developing a more appropriate measure of the opportunity cost of liquidity, e.g., effective cost of credit for borrowers and rate of return on next alternative

TABLE 3: Linear Regression of Factors Affecting Use of Modern Rice and Wheat Varieties and Fertilizer in Surat District, India, 1971-72

	Modern Varieties[a]		Fertilizer
	Rice	Wheat	
Credit[b]	0.182* (2.02)[c]	-0.114 (-1.57)	82.676* (4.28)
Assets	0.020* (2.52)	-0.005 (-0.89)	-0.585 (-0.34)
Non-Agricultural Income	0.089 (1.38)	-0.016 (-1.28)	8.575 (1.18)
Dairying Income	0.100 (1.54)	0.073 (1.53)	25.656* (2.49)
Acreage Under Crop[d]	0.661* (6.59)	0.541* (3.84)	66.998* (4.78)
Gross Cropped Acreage	-0.056* (-2.17)	0.006 (0.29)	--
Acreage Under Improved Rice	--	--	54.359 (2.48)*
Acreage Under Traditional Rice	--	--	18.513* (2.50)
Acreage Under Unirrigated Crops	--	--	-8.991 (-0.89)
Education	-0.005 (-0.12)	0.076* (3.23)	-5.129 (-0.97)
R^2	0.76	0.74	0.63
Number of Observations	59	56	25

a/Two other variables, number of family workers and home consumption requirements were included in these equations but were not statistically significant.

b/Refers to maximum amount the cooperative would be willing to lend the farmer for variable inputs based on acreage, cropping pattern, assets, and character of the farmer.

c/Figures in parentheses are t-value. Asterisk indicates significance at 1 percent level.

d/For fertilizer, this represents acreage under high yielding rice varieties.

* Statistically significant at 1 percent level.

Source: [35].

use of liquidity, instead of the usual dummy variable representation of borrowing or borrowing limits.

Efficiency Gap Function

The third econometric approach relates credit not directly to input levels but to the farmer's ability to efficiently allocate resources. These studies attempt to determine if loans explain differences in ability to use optimum levels of inputs. Some studies simply compare whether borrowers and nonborrowers equate prices of inputs to marginal value products for inputs frequently financed by loans [29, 33]. Separate production functions are estimated for borrowers and nonborrowers but differences in initial level of savings, managerial ability, and perception of risk are usually not considered. A Malaysian study is an exception as farmers were classified by capital availability index, rather than borrower and nonborrower, to correct for differences in financial constraint [12].

A study by Mandac and Herdt was mainly concerned with identifying efficiency constraints on Philippine rice farms, but it represents an alternative approach to measure loan impact. They used a unique data set including production activities from normal farming operations as well as from experimental trials conducted on the farmers' same fields. Measures of technical versus allocative inefficiencies were identified for each farm.[8/]

8/ Farrel distinguished technical from allocative efficiency. A technically efficient farmer operates on the frontier production function. Allocative efficiency refers to equating marginal value product to input price.

Level of technical knowledge, and environmental factors such as irrigation and soil fertility were expected to influence technical efficiency, while managerial ability, uncertainty and perception of risk, financial constraints, and credit availability would likely affect allocative efficiency.

Table 4 reports the regression analysis explaining differences in allocative efficiency among sample farms. Considering the cross section nature of the data and the measurement problems in estimating efficiency, a remarkably high percentage of variation in efficiency was explained by the model. Most of the significant variables are measures of financial constraint--total area, gross family income, and credit--and the signs of the coefficients were as expected. Farm size reduces supply of liquid capital per hectare, while family income and credit increases the supply. The highly significant coefficient for irrigation indicates the importance of risk factors in farmer decisions. Variables reflecting farmers' knowledge seem to be relatively less critical, although the information index and days worked off-farm had significant coefficients.

Efficiency gap models are conceptually appealing and future analysis can be extended to estimate loan impact on farm production or income. However, use of experimental data to establish the frontier production function and thus distinguish technical vs. price efficiency is rarely possible. In many cases, farm practices of the "best" farmers may have to be used as in other empirical studies of technical efficiency [42].

TABLE 4: Regression Analysis of Factors Affecting Variation in Allocative Efficiency Among Philippine Rice Farmers

Variable	Coefficient	t-value
Intercept	1.7490	
Intercept Dummy Variables		
Credit (1=nonborrowers)	-0.4369*	-2.1260
Labor Scarcity (1=scarce labor)	0.0249	0.0913
Tenancy (1=share tenant)	-0.2836	-0.8203
Irrigation (1=unirrigated)	-0.0075*	-3.2051
Risk Index (1=higher risk)	-0.1302	-0.6500
Gross Family Income	0.00003*	3.0000
Total Area	-3.0731*	-9.5497
Information Index	0.1713*	1.8013
Age of Farmer Operator	-0.0091	-1.0225
Years of Education	-0.2418	-1.2002
Number of Days Worked Off Farm	0.0026*	2.0813
Technical Knowledge Score	0.0397	0.4091
R^2 = .77		
n = 336 (56 farmers from wet season of 1974 to dry season of 1977)		

*Statistically significant at 10 percent level or higher.

SOURCE: [27].

Programming Studies

Several studies of loan impact and demand have used some type of mathematical programming. Part of the attraction is that these studies provide estimates of normative behavior; that is, they suggest what farmers should do to achieve a goal specified in the model's objective function. Therefore, they are frequently used to simulate the impact of alternative policy changes.

Modelling Alternatives

Table 5 lists examples of the evolution in programming studies dealing with some aspect of agricultural finance. Single period linear models are most commonly used. Typically, a representative model is developed for reasonably homogeneous farms with respect to size, enterprises, technology, resource endowment and other characteristics. Profit maximization is normally assumed, subject to maximum and minimum farm and/or household constraints. The activities included represent what exists or what is expected under alternative scenarios. Formal and informal loan sources supplement internal funds to finance operating costs.

Multi-period models, with and without discounting future cash flows, provide important advantages for the study of impact of loans on investment, firm growth and liquidity management. First, monthly or seasonal constraints for borrowing or consumption may be specified within a model for a longer planning horizon. Sales activities can also be incorporated to furnish funds for the capital constraint. Second, periods can be linked to show how current activities influence future activities. Third,

TABLE 5: Characteristics and Selected Results of Mathematical Programming Studies of Agricultural Credit

Authors & Study Area	Study Objectives	Objective Function	Selected Model Characteristics	Financial Component	Illustrative Results
SINGLE PERIOD LINEAR MODELS:					
Agarwal & Kumawat; Rajasthan, India	Estimate credit requirements of new technology	Maximize net farm income	Three farm size groups; wet & dry seasons; simulations with & without formal credit and new technology	Initial cash balance; operating credit borrowing limits	Optimum farm plans with existing technology require borrowing; borrowing requirements sharply increase with new technology
Patrick; N.E. Brazil	Analyze possible effect of government policies	Maximize net farm income	Various sizes; three counties; crops & livestock; simulation of alternative technologies, fertilizer & crop prices, land purchase, & interest rates	Operating & investment credit from formal sources	Reductions in fertilizer prices & interest rates had little impact except on income distribution
Whitaker, et al.; INCORA borrowers, Colombia	Analyze impact of credit program	Maximize profits or production	Twelve technology classes of farms; corn enterprises only; simulations with & without credit, and with & without credit tied to inputs	Working capital borrowing limits	Working capital is a constraint; INCORA loans had significant impact on profits, production, factor use & technological change
White; Minas Gerais, Brazil	Analyze regional development potential	Maximize net farm income	Twelve typical farm situations; crop & livestock; simulated technology, borrowing limits, interest rates & specialized credit programs	Operating & investment credit from formal sources	Borrowing capacity limited adoption of technology; results insensitive to interest rates
MULTIPLE PERIOD LINEAR MODELS:					
Ahmed; Gezira, Sudan	Analyze supply & demand for credit	Maximize profits	Six farm types; 24 semi-monthly periods; minimum consumption constraints; production & marketing; parameterized interest rates & borrowing limits	Initial cash constraint; formal & informal credit	Borrowing required to reach optimum income; increased interest rates had little effect on income
Alexander; West Java, Indonesia	Analyze policy alternatives for Bimas program	Maximize net farm income	Six farm types by liquidity & size; consumption constraints; off-farm business specified; three crop seasons; parameterized interest rates, credit allocation rules, payback period & credit in-kind	Borrowing & savings activities; borrowing limits for each type of credit	Interest rates could be raised to 5% per month with little effect on borrowing; increasing credit cost altered marketing practices
Baker & Bhargava; Uttar Pradesh, India	Analyze liquidity management	Maximize farm returns plus values of cash & credit reserves	Small farm; wet & dry season; minimum crop & cash requirements; reserve values for cash & credit	Borrowing from moneylenders & small farmer credit program; parameterized cash & liquidity requirements	Models with reserves concept approximate farmer plans; reliable sources of small farmer credit increase output & income
Hadiwigeno; East Java, Indonesia	Analyze effect of changes in credit policy	Maximize farm net income plus value of cash & credit reserves	Small farms in four villages; one year planning horizon; six seasons; padi & other annual crops; minimum household pati; simulated changes in Bimas credit	Borrowing from moneylender, bank & Bimas program	Changed terms for Bimas loans, affected marketing; little effect on production; little effect of increased interest rate

MULTIPLE PERIOD LINEAR MODELS (DISCOUNTED FUTURE INCOME):

Dean & Benedictis; Southern Italy	Analyze optimum investment behavior	Maximize discounted future net farm income	Small farm; 60 year planning period; annual & orchard crops; exogenous consumption requirements	Government production grants & interest subsidies; 8% discount rate	Rapid conversion to orchards with/without grants; a discount rate of 16% would lead to annual crop production
Naseem; Punjab, Pakistan	Analyze effect of government policies on growth	Maximize discounted future net farm income	Small farm; four year planning model; winter & summer seasons; simulated borrowing limits, savings rates, interest rates, product prices & farm size	Borrowing & savings activities	Credit constrains full use of resources; farmers would borrow triple initial credit availability at prevailing interest rates; shift to higher-value crops & improved technology with credit

MULTIPLE PERIOD RECURSIVE LINEAR MODELS:

Day & Singh; Punjab, India	Analyze agricultural transformation	Maximize regional net farm profits each year	Regional model; regional cash & consumption constraints; feedback constraints; historic behavior 1952-1965; projections to 1980	Borrowing & savings activities; credit tied to gross sales; operating & investment credit	Increasing internal finance over time; elasticity of demand for loanable funds increases
Heidhues; Northern Germany	Analyze policy alternative effect on firm growth	Maximize net farm returns each year	Eleven farm size-types; year planning period; feedback constraints; simulated grain & milk prices	Several money & capital constraints; investment & savings activities	Investments lower on farms with reduced internal finance
Singh & Ahn; Rio Grande do Sul, Brazil	Analyze regional development process	Maximize regional net farm income	Three farm size models; crops & livestock; 10 year period; feedback constraints; simulated alternative credit & price policies	Operating & investment credit from formal sources	Derived demand for credit showed increasing elasticity over time; small farms were relatively insensitive to interest rates

SINGLE PERIOD QUADRATIC MODELS:

Peres; Sao Paulo, Brazil	Estimate derived demand for credit under risk and inflation	Minimize variance of farm income	Small and large farm models; crops & livestock; price expectation model; parameterized interest rates & labor supply	Initial savings; borrowing limits for credit for modern inputs & general expenses	Actual borrowings exceeded predicted for small farms, while large farms borrowed less than predicted
Schluter; Surat District India	Analyze cropping pattern	Minimize mean absolute deviation of cash income (MOTAD)	Typical farms; irrigated & non-irrigated farms; annual crops; minimum consumption constraints; parameterized family size; farm size; wage rates & interest rates	Savings & borrowings from moneylender & cooperative; borrowing limits for formal & informal credit	Credit was required for production of high-income crops; interest rate had little effect
Soares; Northeast Brazil	Determine optimum resource use under risk	Minimize variance of farm income	Large farms; one cropping season; simple & inter-planted crops; sharecropping; parameterized technology, cotton prices, wages, labor supply, borrowing limits	Cash constraints; formal credit	Fifty percent reduction in formal credit borrowing limit reduced sharecropping & farm income, while increasing income variance

future cash flows can be discounted to account for the time preference of consumption when the planning horizon is several years.

In addition, some specific issues have been studied with multi-period models. For example, Boehlje and White compared results of maximization of income versus net worth. Baker and Bhargava and Hadiwigeno tested how the value of unused cash and credit could influence liquidity management.9/ If the value of credit reserves is high, farmers may engage in internal credit rationing and borrow less than the full borrowing limit. Likewise, when the reserve value of cash is high, farmers may borrow even while holding cash.

Recursive models have been used to model both representative farms and agricultural regions. Unlike other multi-period models, the objective function is solved each year with the results for one period linked to previous periods by feedback constraints. These constraints are specified to reflect farmer behavior, such as accounting for risk aversion by safety first objectives [39]. Some tests exist for verifying model results relative to historical experience [18]. Another feature of regional models is farm size decomposition to test competition for resources, such as a fixed regional credit constraint, among different size farms [39].

Another approach to treating risk exists with quadratic models used to generate EV frontiers relating expected income

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9/ Recently, a similar analysis was conducted by Tewari and Sharma.

to income variance. Farmer behavior usually approximates some point along the frontier where income and capital requirements are somewhat less and enterprise combinations more diversified than obtained with profit maximization.

Two types of analyses are frequently conducted in programming studies. The first is similar to the before-after approach discussed earlier. Solutions of models without loans or with only informal loans are compared with solutions specifying borrowing limits for formal loans. This approach conforms with the resource allocation model discussed in the first section where loans are expected to influence input usage. The second analysis involves parameterizing the interest rate for formal loans to determine levels and elasticity of loan demand.

Several similar results emerge from these studies. Technological change, adoption of new varieties and cropping systems, mechanization and farm income are frequently found to be constrained by current formal loan supplies. Borrowing limits must be relaxed to obtain socially desired changes in these variables. Likewise, evaluations of credit programs conclude that formal loans have resulted in desirable farm changes. Furthermore, productive alternatives exist so farmers could pay substantially higher interest rates with limited reduction in borrowings. Small farms appear particularly insensitive to interest rates.

Methodological Problems

The similarity of research results would normally suggest conclusive evidence on these issues. Several methodological issues, however, require caution in interpretation. The actual or expected impact of borrowing or demand for loans may be substantially under or overestimated in a particular study because of several reasons. First, few studies attempt to capture the full complexity of farm household behavior. Model activities are largely limited to the farm and only Alexander included the allocation of household resourcesto off-farm business.10/ Since loan funds are fungible, the true impact of loans for production purposes is hard to determine without an integrated household model. Furthermore, savings behavior should be tied to production possibilities so a fixed level of savings should be inappropriate when technology changes.

Second, many studies focus on working capital. In many countries, little long-term credit exists. Therefore, short-term loans are borrowed in excess of working capital needs to help finance investment. Thus the impact of short-term loans must be considered in relation to investment, not just production as is normal.

Third, true costs and benefits of borrowing may not be adequately captured by interest rates and borrowing limits. Borrowing costs, especially for small farmers, may far exceed interest rates [1]. Also, the reliability of the credit source, expectations about the need to repay, and noncredit services will influence the extent to which a borrower will switch from an informal to a formal source or borrow rather than use savings [8].

10/ Bishop appears to be one of the first to analyze nonfarm activities.

Fourth, in spite of subsistence constraints, valuation of reserves, safety first constraints, quadratic programming, etc., it is not clear that research has adequately dealt with risk and uncertainty. If credit were priced at equilibrium rates, repayment expected, and farmer attitudes toward risk adequately captured, optimum borrowing might be significantly less than estimated.

Fifth, compared to some other methodologies, mathematical programming models offer fewer possibilities for statistical tests of goodness of fit. In this review, only two publications dealt with model validation in any detail [18, 39]. Some models may be so tightly constrained with (sometimes) arbitrary constraints that few feasible solutions are possible. Thus it is not clear if farmer behavior has really been captured by the models. If not, projections are dubious.

Finally, this review would not be complete without reference to the applicability of these models to many low income countries. Many sophisticated models have been developed in developed countries. Few low income countries have sufficient data, computer capability and staff to use these models.

SUMMARY AND DIRECTIONS FOR FUTURE RESEARCH

This paper has addressed methodological problems in analyzing the micro level impact of loans. The first section reviewed the farm resource allocation model explicitly or implicitly underlying much research. The second section reviewed selected examples of empirical research. Many studies are largely descriptive and are more useful in generating hypotheses than in rigorously assessing loan impact. The more analytical econometric and mathematical programming studies are relatively few, are confined to a few countries, and also have methodological problems.

Three important methodological issues were identified. First, most studies use the farm as the basic unit of analysis. Little attention is given to the interdependence of production and consumption activities typical in most farm-households in low income countries. This shortcoming is sometimes justified by the explicit goals of agricultural credit programs of increasing farm production, but also may be due to inherent complexity of conceptualizing a broader framework and the traditional separation of production and consumption theory in neoclassical economics.

Secondly, and related to the first, few studies recognize the fungibility of money. Borrowed funds enter the household's total cash resources and become indistinguishable from other funds. Funds ostensibly obtained for farm production may result in additionality in consumption or nonfarm activities. A narrow focus on farm analysis will tend to understate the credit impact on farm-household welfare and fungibility creates difficulties in assessing this bias.

Third, most studies have not adequately resolved the attribution problem, that is, separate the effect of loans from other factors simultaneously affecting farm production, yields, income, etc. Differences in output and input prices, production technology, and managerial constraints may all contribute to differences found between borrowers and non-borrowers or before and after borrowing. Especially important is nonprice rationing of credit resulting in concentration of loans to larger, well-established, richer farmers. Thus, differences between farmers may explain credit allocation rather than the impact of borrowing.

Future research on rural finance will improve as researchers develop greater appreciation for the issues raised in this paper --interdependence of farm-household decision-making, fungibility, and attribution. The input demand and efficiency gap econometric models illustrate potential analytical approaches for measuring loan impact that minimize the attribution problem. Likewise, some of the recent programming models attempt to capture more of farm household complexity and interdependencies. New methodological approaches using a integrated farm-houshole framework of production and input demand and supply analysis have not been explored extensively for financial studies [26].

The immediate priority is to develop a data base sufficient for more detailed analysis of agricultural finance. Fungibility and farm-household decision-making indicate the need for collecting comprehensive data on sources and uses of farm household liquidity. All sources of liquidity need to be quantified and related to the various farm and household uses. Careful monitoring of production expenses, investment, consumption and nonfarm activities is necessary to accurately describe when and where additional liquidity is allocated. Once described, more rigorous analysis can be used to identify factors explaining allocation and impact of loans. Massive cross section surveys currently undertaken in many countries are not suitable for this purpose. Much more emphasis is required in carefully collecting longitudinal data, particularly from panel households, even at the expense of smaller sample size.

Finally, the ultimate objective of agricultural credit policies and programs should be to improve rural welfare. Although the benefits and shortcomings of credit are frequently enumerated, they have not been systematically related to the costs of other policy instruments to meet the objectives including input or product price policy, irrigation development, research and extension, and so forth. We suspect such an analysis would reveal that agricultural credit programs are less cost effective, but are preferred because of ease in administration, facility with which rich politically powerful farmers can manipulate them, and ability to absorb large sums of money thereby assisting aid agencies to meet lending quotas.

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